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THE BRITISH COMPUTER SOCIETY

At the inaugural meeting of the London Computer Group, all the speakers emphasized, and the meeting accepted, the need to seek the widest possible basis of membership covering all interests and to pursue the concept of a truly national society, in whatever form such an organisation might be evolved. In fact, one of the objects of the Group adopted at that meeting was to "cooperate to the fullest possible extent with other similar organisations with a view to the formation of some national organisation". It may seem a comparatively simple matter to get people who are interested in forming such a society to sit round a table and to evolve the way they should do it. But we have to bear in mind the great diversity of interests in the field of "computational machinery and the techniques allied thereto".

Firstly (and we must give them pride of place) there are those, primarily mathematicians and scientists, who have evolved the techniques on which the machinery is based; secondly there are those, mostly engineers and designers, who have developed those techniques into working machines and components; thirdly there are those, mainly component and machine manufacturers in the electrical and engineering fields, who make the instruments and hope to sell them; fourthly there are those in every field of human activity involving calculation, who have to use the machines with all their related problems of application, organisation and administration.

Already many professional bodies were watching over the interests of their own members who have special interests in the electronic computer field; at some conferences of such bodies seeking common ground there have been about 30 organisations represented. In these discussions over the past year (and there has not been any conference of importance at which the London Computer Group has not been represented) it was immediately clear that there was general agreement on at least one point - a national organisation was not only desirable but was essential so that this country could be adequately represented and her opinions given due weight in international affairs.

Following meetings sponsored by the engineering institutions, there has been formed the British Conference on Automation and Computation, set up to provide a channel for the presentation of the British Point of view in international discussions and to act domestically in Great Britain as a clearing house between the many societies in the automation field. This wide field falls naturally into three broad divisions, covering the engineering applications of automation techniques, the development and application of computers, and the sociological and economic aspects of automation. (continued on page 3)

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THE BRITISH COMPUTER SOCIETY

The London Computer Group's interest lies mainly in the second division of the field, and the British Conference on its formation let it be known that any truly national computer society, with broadly the same aims, would be welcome to join the conference when such a national society came into being.

This possibly gave a spur to efforts being made in other directions to weld together the many individuals interested in computational machinery and its application. It was generally recognised that the London Computer Group had played an important part in initiating the concept of a society of individuals, with a common interest from different viewpoints, in which individual engineer and manager, scientist and accountant, statistician and banker, mathematician and local government official could meet and discuss not only mutual but overlapping problems.

At the same time the London Computer Group could not be said to be a truly national organisation, although the Committee has always envisaged the function of the Group as a means whereby this integration of interest could be achieved, believing that the true use of data processing and computer techniques in industry and commerce generally lay not solely in simple clerical and accounting data processing, but in the much wider integration of these with industrial calculation and planning, production control and allied techniques, until one reaches the ultimate integration whereby one installation, or even one process, can serve every purpose of an industrial concern in every aspect of management and production information.

The evolution of a national organisation might have been achieved in one of two ways:

firstly, for a number of bodies, each with its own particular specialist or regional interest (of which the London Computer Group would be one such body) to be affiliated to a central body or in some other manner to be united under one label, or

secondly, to form one society in which each individual would be free to benefit from every interest and within which certain specialist and/or regional groups could be formed without, however, these groups being open to specific membership or in any way limiting

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the degree to which an individual would be free to participate in any activity of the Society as a whole or of any one Group.

The Committee of the London Computer Group, after careful consideration, have preferred the second of these two alternatives. They felt the first would duplicate the aims of the British Conference and would not follow the concept of a society of individuals with all the benefit of personal contact and exchange of personal experience.

It is also extremely difficult, if not impossible, in many fields of computer application, to draw a dividing line where, let us say, clerical data processing ends and production control begins, or where the calculation and planning of machine loading is to be separated from calculations relating to the manufacturing process, or where pure arithmetical calculation in, for example, an Assurance Company can be clearly distinguished from clerical recording of the company's transactions. There are no clean, sharp lines in this field. Indeed, by seeking to define them one would be preventing integration of interest and, by implication, the integration of computer applications over the wide range of their possible uses.

Following that decision, it became possible for the Committee to meet representatives of other and wider interests, such as scientists, mathematicians and engineers, on the basis that a national society should be formed of individuals without vested interest by membership of particular sub-groups. The result of these discussions has been, as announced in the press, the formation of the British Computer Society. Within that Society, whose objects are so closely in line with those of the London Computer Group as to be almost indistinguishable except for their wider basis, there will be both Regional and Specialist Groups, watching over the interest of any particular section of members who may apply to have that interest recognised and represented on the main Council, but there will be no individual membership of these groups.

There are still many details to be worked out, but it has already been agreed that the first Council, under an eminent President of the Society, will be formed of seven members of the Committee of the London Computer Group, seven others well known on the scientific and mathematical side of computer development, with a representative of each specialist or regional group as its formation is approved by the Council. The first two such groups will be the Business Group, catering primarily for those members of the London Computer Group whose interests lie mainly in the field of clerical data processing, and the Scientific and Engineering Group.

It has also been agreed that the British Computer Society will accept without any further entrance fee or subscription all current paid-up members of the London Computer Group as full members of the Society, whose activities are planned broadly on the same lines as those of the London Computer Group but covering a wider field.

The Study Groups, with their particular interest for business users, will be sponsored by the Business Group.

The Society proposes to publish a quarterly journal in addition to a more frequent bulletin; the earlier numbers of the latter, since they contain material directly relating to the past activities of the London Computer Group, will be published as the London COMPUTER Group BULLETIN.

Already well advanced in production in the early part of this year, publication of this first issue of the COMPUTER BULLETIN has been delayed so as not to embarass those engaged in the negotiations leading to the Society's formation. It was felt that the birth of a new publication, however modest, at an inopportune moment might have caused some to think that the London Computer Group was taking unilateral action. The successful outcome of all that we have been working for now allows the COMPUTER BULLETIN to make its bow. To our contributors, for their willing work in revising and editing their spoken word, and to our advertisers, for their faith and forbearance - our sincere thanks. To the British Computer Society, whose future growth and development we will be privileged to record - our sincere good wishes.

KIASMUS

EXPERIENCES OF USING A DIGITAL COMPUTER IN INDUSTRY - 1

L. GRIFFITHS
CHIEF COMPUTING ENGINEER
ROLLS-ROYCE LTD.

(From a lecture given to the LONDON COMPUTER GROUP on 18th February 1957 at the Caxton Hall, London)

This lecture is being published in two parts. The first, in this issue, gives an historical survey of the Computer Office at Rolls - Royce Ltd., leading up to their present machine complement, and describes some technical applications of the equipment. The second part, to be published in the next issue, covers financial and production control applications, staff and procedures, training of staff and education of running departments, and some running statistics.

HISTORICAL

1 I shall begin by developing the history of the Computer Office at Rolls-Royce Ltd., as this will provide you all with a background which will enable you to have a better understanding of subsequent points and will also allow you to draw conclusions as to the worth of our methods as applied to your own environment. Let me say at once that the systems and staff arrangements that we have designed for our use may not necessarily be of general application as we have naturally endeavoured to tailor them to our needs. Further, at the present stage of the computer and data processing art, nobody, either manufacturer or user, can pretend to be expert, however much relative experience he may have had. It is a field in which everyone has something to contribute.

2 The installation was born in September 1953 without any electronic equipment included in the machine complement and it was the intention at that time to use the equipment solely for engineering calculations in the aero-engine division. The main unit was a type 602A electromechanical calculator with 80 column punched card input/output which had limited storage capacity amounting to 96 decimal digits and which was programmed by means of pluggable panels. The installation contained in addition a small complement of standard punched card accounting equipment; namely, one tabulator, one sorter, one reproducer, one collator, and two key punches and one verifier for manually raising data on to punched cards. This equipment was primarily obtained to determine, for manufacturing purposes, the co-ordinates of points at specified intervals round the peripheri of sections of aero-engine compressor blade forms - in other words to produce the manufacturing details from design scheme data. The urge to obtain automatic equipment to produce these calculations came from the fact that the existing drawing board methods were creating a bottleneck in our blade production program and, in addition, the required accuracy was not being maintained on certain types of blades. The programming of the calculator pluggable control panels had been completed prior to the installation of the equipment.

The first day and a half was spent checking out the wiring of the six control panels required for the compressor blade detail job and we then went into production to meet not only the demands of the current blade program but also to catch up on the backlog that had been steadily growing.

3 The circumstances were not ideal as I had at that time three staff responsible to me, none of whom had previously used punched card equipment and it was thus necessary to train them on calculations that were intended for use by the production departments. The results however, were encouraging although in this initial period we must admit to a small proportion of errors, only one of which got to the manufacturing stage, the errors being entirely due to the use of untrained staff. The experience was very useful however, as it served to emphasise the absolute necessity for the fullest possible planning and for training programs being carried out prior to

the installation of any automatic computing equipment, however small in capacity.

4 As we had estimated prior to machine installation, the blade detail calculations only used 50% of the capacity of the 602A Calculator (working one shift). We therefore looked around the technical departments for the most suitable applications for utilising the spare capacity of the machine. Very naturally, we found in these early days a strong distrust of automatic calculating equipment amongst the engineers and heads of technical departments. Thus it was important that the new applications we chose should give us experience of work which would be in important fields of application in the future and further should be sufficiently general to overcome the inherent distrust of as many departments as possible.

5 The applications we chose were

(a) analysis of aero-engine compressor tests to determine the stage characteristics,

(b) stressing of compressor and turbine discs for centrifugal and thermal stresses,

(c) calculation of deflection coefficients of shaft systems and blades with in addition, a limited number of matrix operations to assist in determining the critical frequencies of blades and shafts, and

(d) the analysis of Wind Tunnel test data.

6 All these applications were succesful in that the machines reliably produced the required answers and, further, it was noticeable that departments had lost most of their early inhibitions and were approaching us, of their own volition, to ask for mechanical assistance with their calculations. As a result, the machine was very rapidly loaded and we were forced to look around for larger equipment if we were to meet the growing demand.

7 Before going on to outline briefly the equipment we obtained next, it is perhaps appropriate to remark that we had found our original choice of punched cards as our main medium a very happy one as not only were we able to raise our information manually in volume with maintained accuracy but we were at all times sufficiently flexible to meet with ease all anomalies and surprise alterations to the work.

8 It was obvious that the next machine we obtained must depart from the principle of the programming being limited to a pluggable control panel, because not only were we accumulating a very large number of panels but as every job had to be split down to a comparatively large number of runs on the 602A, each with its own control panel, there was an excessive number of operator interference points each with a danger of human error. It should also be stated that we were not at this stage prepared to go into the digital computer field proper, as we felt that the available machines were not at that time sufficiently advanced to warrant a large expenditure. We were thus after a machine to fill a gap for what we considered would be a comparatively short period.

9 The machine we chose was the IBM CPC - or Card Programmed Calculator, which is a partly electronic, partly electromechanical calculator with four machine units interconnected. The four units were respectively a tabulator which also served as a card input, and contained positions of electromechanical storage, a card punch as an alternative means of output to the print mechanism on the tabulator, an electromechanical storage box with a capacity of 216 decimal digits, and an electronic calculator. It is interesting to note that during the period intervening between the ordering of the equipment and its delivery, the demand for our computing service had snowballed to the extent that three CPC's would barely have been sufficient for our needs. It was at this time therefore that we initiated an investigation to determine the digital computer that we should obtain as our next piece of equipment.

10 The work we loaded on the CPC was entirely of technical and engineering application but we attempted to satisfy as many of the departments as possible consistent with the Company's policy on priorities. We naturally enlarged our test analysis work to include reduction of development engine test bed and flight test results. Other spheres of work in the Aeroengine Division from which we chose and programmed applications included stress, vibration study, performance, aerodynamic and combustion. The machine also made an extremely useful contribution to early work on atomic reactors.

11 The total staff complement had risen by this time to ten.

12 This then was the sum of our experience when we became actively interested in obtaining a digital computer.

13 At the same time as we had been gathering experience on the technical side, the financial and production administration had also become keenly interested in the possibilities of a digital computing system for their type of data processing. As a result a combined team was formed to investigate the possibilities of the various computing machines both in this country and the United States, the object being to obtain a medium sized digital computer which, when installed, would be used to 80% of its capacity on technical and engineering problems, and the remaining 20% would be utilised in gaining useful experience by running a number of typical financial and production problems, primarily as experiments, but where suitable as running jobs.

14 Although we realised that magnetic tapes would be essential to any full scale application of computer techniques to our large data processing problem, we restricted our choice quite intentionally to a card input/output machine. We felt that we were well placed to do this as at that time we were early in the financial and production control data processing field. It was further felt that as the machine would be used largely for scientific and engineering calculations - and could therefore be justified costwise by these applications alone - we would have a relaxed atmosphere for trying out and evaluating our data processing experiments. In other words we would not be rushed into this type of work to justify heavy cost of equipment. The value of this cannot be overstated.

15 This brief historical survey then ends with the installation of the medium sized computer we chose, namely the IBM 650. As you all probably know, this is a card input/output machine with a universal drum store with the equivalent capacity of 2,000 ten decimal digit words (this being the standard word length of the machine). The main features of this machine are its reliability and its completely automatic checking facilities

16 We chose punched cards as our input and output medium for the following reasons:-

(1) A lot of our technical work involved the processing of a large volume of test results and it was clear that the speed of paper tape output was not adequate for this type of work. This obviously also applied to all commercial and production data processing applications.

(2) Punched cards provide probably the best medium for conveniently raising data manually in large volume, with high accuracy.

(3) Both in our computing installation and in our commercial and production departments we had accumulated considerable experience of punched cards.

17 It is probably worth mentioning here that because we were able to obtain the 650 on four months' delivery and the time of the year was not a convenient one for recruiting staff, we took over the machine with the bare minimum of previous planning and programming and without a full complement of programmers. Despite this we were able to justify two shift working on the computer in August of last year, that is, seven months after installation of the machine.

18 The staff complement at the time of installation of the 650 was 18, made up of 6 programmers, 3 operators, 6 punch and verifier staff, the remainder consisting of supervision and typing staff.

19 During the latter half of 1956 the staff was steadily built up to a complement of 43, which included 16 programmers, partly in readiness for a 650 magnetic tape computing system which we expect to be installed as an addition to the basic 650 in the early spring of this year.

20 On average we currently use the basic 650 to good purpose for production or program testing for 134 hours per week. This does not include scheduled maintenance or unscheduled breakdown.

MACHINE COMPLEMENT

21 Before going on to discuss our experience of running a digital computer, the structure of our staff system, and some of our methods, I would like to outline briefly our existing machine complement.

22 In the computer installation itself and besides the 650 computer, we have a range of

standard punched card accounting equipment which is made up of two sorters, two reproducers, one collator, one interpreter, one tabulator, one paper tape to card converter and one plotting machine for which we use one of the reproducers as a card input. This equipment has been obtained in sufficient quantity to guarantee that the computer is never held up for card information even at card peak load times. No attempt is currently made to justify the efficiency of this standard punched card equipment on any other basis as we are essentially a computing organisation and in addition the computer is by far the most expensive unit of apparatus that we have installed.

23 Apart from the apparatus already mentioned we have a section of nine key punches and six verifying machines. Not all of these are required for the current installation but we have had machines extra to our requirements installed for some time to train extra staff for the magnetic tape machine and to prepare the data that will subsequently be stored on magnetic tape reels.

24 The magnetic tape computing system to be delivered shortly will include the facilities of the basic type 650 with in addition 4 magnetic tape read/write units, a small high speed computing store of magnetic cores, two punched card input feeds (one rated at 200 cards per minute and the other at 150 cards per minute), two punching mechanisms for outputting cards at respectively 100 and 60 cards per minute, a line printer capable of printing 120 alphanumerical characters per line at 150 lines per minute, and a sterling conversion unit. The machine will also have a duplicate set of arithmetical circuits for floating decimal operation and will include 3 indexing accumulators.

25 We will in addition increase our existing complement of standard punched card equipment by one reproducer, one sorter and two interpreters.

26 In addition the Company has comparatively recently installed a small set of standard IBM punched card equipment in our commercial punched card installation to supply us with data cards for the computer runs we do on financial and production problems.

TECHNICAL APPLICATIONS

27 As much of the interest of this meeting would appear to be in commercial data processing I will deal only briefly with our technical applications despite the fact that currently they represent the major part of our work.

28 The scientific and engineering calculations that we have programmed for and used on the basic 650 fall naturally into a number of broad types. Test data analysis work usually involves a large volume of input and output with only a comparatively small amount of calculation - in other words, this type of work is similar to commercial data processing problems in terms of the required input, output, and calculating capacity.

29 Another type of problem involves heavy calculation with comparatively small input and output volume - the mathematics not being extremely involved. Aero-engine performance synthesis and disc stressing calculations are good examples of this type of work.

30 The last broad type of computing problem that we handle in our scientific and engineering applications is that which involves us in advanced numerical analysis techniques at the programming stage.

31 A factor which has carried considerable weight in our recruiting of staff for programming work and in our choice of the number of programmers required is that between 30% and 40% of the scientific and engineering calculations that we program for the computer are 'one-off' in nature - that is, the program for this type of job is only utilised once on the computer. To make this type of job worthwhile it is often necessary to be able to program and test it in a very short space of time.

32 Our service now extends to most of the technical departments of the Aero-engine Division in Derby and district involved in calculation work and also includes a service to our Reactor and Rocket Engine Groups.

33 There are two logical stages in developing automatic computing facilities with the object of improving the technical quality of the products of a Company in the aero-engine industry.

34 There will be no measurable increase in the quality of the product as the direct result of the first stage of development. This period will inevitably be confined to relieving departments of their repititive calculations, which can be done more accurately, faster, and in more detail than is

possible by manual methods. The computer does at this stage allow more and more qualified and experienced technicians and engineers to perform the work for which they were recruited; that is, to apply their skills and experience to achieving a better product rather than to spend a large proportion of their time operating slide rules and desk calculators in repetitive but necessary calculation. Further, as the Company increases its commitments and fields of activity the computer is able to reduce somewhat the numbers of extra technical and engineering staff required.

35 In addition to these tangible benefits, this first period of operation allows the technicians and engineers to obtain a measure of the potential of automatic computing and, more important, it gives them the necessary time to think and to collaborate with the Computer Office in achieving the second stage which will allow the computer to make a direct contribution to the quality of the firm's products.

36 We firmly believe that at Rolls Royce the computer installation has passed through the first stage of development and is now making a direct contribution to the technical quality of our products.

37 A good example of this is the contribution we have already made to performance synthesis calculations. We have devised a number of programs of this type for some of our engine types. The programs contain all the measured real component characteristics of an aero-engine, take account of tappings off for auxiliaries and bleed air flows, and include as variables all the significant passage areas and fuel functions. These calculations covering the engine working range are completed in a matter of hours and they are factual, and not theoretical, as they are based on measured results, obtained during component tests.

38 By hand methods the performance departments could not hope to do these calculations in the detail that would make them of value since many months of hand calculation would be involved in each exercise. Thus in the past a considerable amount of development time was spent, together with a minimum of hand calculation, to determine the desired information. This was expensive both in time and cost.

39 In the current situation in the world's civil markets, the facility for obtaining this data for any engine configuration in a matter of hours is an invaluable asset both because of the time saved, and because the information finally obtained is the optimum from consideration of a large number of possible cases.

40 We shall naturally considerably extend this field of our activity when the 650 magnetic tape computing system is installed.

41 As a considerable proportion of our technical computing is comprised of test data analysis we are naturally very interested in test site automatic instrumentation and transmission of data to our central computer. It is the Company's intention to install a fully automatically instrumented test cell at an early date. This system will produce on the test site a typed copy of the readings and in addition a full recording on punched paper tape. Initially the paper tape will be manually carried to our computer installation and converted on to punched cards. The next step of course will be to transmit the data automatically on to a suitable input medium in the Computer Office.

42 We have already installed an automatic plotting table which is capable of translating our computer output data on punched cards to a plotted display. This will be extremely valuable for use on the performance and test data analysis work.

43 It is perhaps worthwhile mentioning one engineering application which is out of the normal run of technical calculations, namely that of supplying control data to an electronically controlled milling machine for the purpose of automatically producing blade die blocks. Our experiments are at an early stage but we have been able to prove to our own satisfaction that the computer can supply the required details.

(To be continued)

EXPERTISE

"This case [of installing an integrated data processing system for the Canadian National Railways] has taught us many things. . We have learned that the only real experts in this work are those who have never carried the responsibility of an installation: after that you are no longer an expert."
(From Integrated Data Processing - A Case History, by A. A. Mackley, in the Canadian Chartered Accountant, March 1957)

SOME PROBLEMS OF A MAGNETIC TAPE COMPUTER

R. L. MICHAELSON
F. I. A., F. I. S.

From a recording of a talk given to the London Computer Group on 19th November 1956 at the Caxton Hall, London, S.W.1.

R. L. Michaelson began his professional career as an Actuary during which time he made the aquaintance of Powers machines. During the war he learned even more about Hollerith machines, and later joined the British Tabulating Machine Company, soon finding himself interested in the development of the HEC Computer.

In 1955, he joined the Decca Company to take charge of their technical sales group. Since giving this talk he has joined Elliott Brothers (London) Ltd.

INTRODUCTION

1 The object of tonight's meeting is to describe a machine which I could dismiss in about three minutes and describe to you as "a magnetic tape electronic data processing machine of the UNIVAC kind" - for those who must pigeonhole everything; it is that class of machine.

2 Now in a sense, addressing many of those here tonight, that description is sufficient provided I add some characteristic speeds and capacities. However, I understand that you would really like to go into a bit more detail regarding these machines, and this, I think, is very proper. Although those of you who are primarily users need only know the functioning of the machine, the more detail you know as to how it works the more you get out of it.

3 Before I get down to more detail of the machine, I want to say to you that, for the first part of my talk, I am going to assume this machine physically exists because it is much easier to speak of it in that way. If I did not do that I would continually have to say "I expect", or "it is suggested", and so on, which becomes very tedious. So for the moment this machine is deemed to exist and later I will give you some idea of its physical status.

RADIX ARITHMETIC

4 I will start by defining the basic unit with which the machine deals. This is a 6 bit character, which can represent any number from 0 to 63.

5 Now the machine is provided with the means of doing what we call Radix Arithmetic, and this is done directly by programming the instruction in the machine. There is a special code in each instruction with which you tell the machine the kind of number that you are dealing with. By that I mean that if we take a group of three digits in the machine, say 1, 2, 3, and another typical group, say, 1, 8, 9, the machine is so constructed that if you add those two numbers together the answer in the machine is 1, 10, 12. However, that is, so to speak, an interim answer inside the machine. The special program is now invoked to define the radix or base of each digit. Suppose for the sake of an easy illustration that all three digits are in the scale of ten, i.e. the decimal scale. The most significant digit (12) is modified by internal circuitry and is altered to 2 with a carry of 1. This is equivalent, of course, to saying that the digit should really be recorded in a mechanism with the same characteristics as the tens wheel in a normal adding machine. The carry turns the next position to 11 and the circuitry modifies this to 1 with again a carry. The third position becomes 3, then the carry is allowed for and no further modification is necessary. We thus reach the three digits 3, 1, 2, which is the correct sum of 1, 2, 3 and 1, 8, 9 if we are in the decimal scale of notation. But this is a very flexible and sophisticated machine.

7 To return to what I called the interim answer when the machine stored, as the sum of 1, 2, 3 and 1, 8, 9, the three digits, we find that we could have told the machine that the scales of notation were, say, 2, 10, 12.

This is something the programmer builds into his program. If that had been the case it would have altered the interim sum of 2, 10, 12 to 1, 1, 1, 0, a fourth significant position being introduced by the carry from the third. The machine has in effect now interpreted 1, 2, 3 and 1, 8, 9 as 12/3d, and 18/9d, and produced a representation of their sum - £1. 11. 0.

8 This flexibility of number representation is one of the basic characteristics of the machine. The engineering behind this is a binary register dealing with three characters each expressed in 6 bits. We have thus 18 bits for the 3 characters. This can be thought of as an 18 bit binary accumulator with special facilities for turning it into an accumulator which deals directly with any scale of notation, provided (this is rather like Mr. Ford saying that his car can be of any colour provided it is black) the scale is less than 32 and is an even number. The only radix which you might meet in practice which I think would not fit those conditions are bakers' dozens. As a matter of fact it is expected that a large proportion of bakery work will be done on another machine.

9 However, a 6 bit character is not the fundamental unit that the machine will take note of: its basic transfer unit is a group of three such characters. I am talking about characters now, not bits, and we call the group of 3 characters a "syllable". Most of you are familiar with the use of "word" in computer language. I now have great pleasure in introducing the syllable! A syllable is a group of three characters plus a sign, so it therefore consists of 19 bits, although of course from the point of view of a syllable used for data the number of bits is quite irrelevant and it should be thought of as three basic characters plus one sign digit. A syllable is also used for a machine order and it is then thought of as 19 bits. I have just said that I am not going into the fundamentals of computers and am assuming that you are all familiar with the basic terminology and know what a quick access store is and what an order is. All I want to say about a 19 bit order is that it splits up basically into a function, a characteristic and an address; the address will be the address of some syllable in the quick access store or some syllable on the magnetic drum.

10 In the literature of the subject, this would be described as a single address code, and having obeyed one order in one position, it will automatically go to the order in the next adjacent position unless there is some conditional or unconditional transfer which causes it to depart from that. The syllable is the basic unit of transfer in the machine, the syllable consisting of three characters. It is arranged like that because it is most economic to make the smallest unit of information equal to the amount which would define an order and we find we do not need more than 19 bits for our order. This very fortunately divides by three and leaves a remainder of one over, which gives us very nicely three complete characters plus a sign for data. Now we combine our syllables into words, and a word may consist of 1, 2, 3 or 4 syllables. When I say "combine" I mean that with this order of 19 bits you have the ability to address a syllable and say how many of the adjacent syllables you are talking about or you wish the machine to talk about. So this allows you to process 3, 6, 9 or 12 character words in a direct manner. You can, of course, always do double length arithmetic, which you can do on any computer, but this, instead of being direct, would be by special interpretative sub-routine programming; but directly, you can have 3, 6, 9 or 12 characters in those practical radices which I have mentioned. This, you will see, is some sort of compromise between those people who advocate a fixed word length to make the machine more simple inside, and those who advocate a variable word length in order to get the most out of your available storage. Whether this is an adequate or a satisfactory compromise remains to be seen in practice, but the advantage is we do not lose a great deal of space by packing information into 3, 6, 9 or 12 character length pigeonholes.

QUICK ACCESS STORE

11 A word on the hardware of this brings one up against one dilemma: there is no valid place from which to start describing any computing system. It is no good starting on the assumption that you have already described some other piece of equipment with which the piece you are describing has to communicate; this comes about because the whole thing is circuitous, wherever you start you find yourself with antecedents. Some people might feel you should start at the input, and follow it forward to the output; that does not work out because the input and the output are the same piece of equipment. So I am going to start with the quick access store.

12 The quick access store would hold up to 2 048 syllables as a standard. You can have

less quite easily and we will debate the need for more. Any one of these syllables can be got out of this thing in 12 microseconds. That, of course, is very fast and roughly the whole point of the scheme is to make that as fast as possible. You will hold in this store both your data and your orders, and you have the ability by a program instruction to take any one of these syllables out of the quick access store, send it to the arithmetic unit and cause it to add or subtract or to be used as a multiplier. The elementary transfers would take place in 12 microseconds, subject to what I am about to say.

13 This 12 microseconds is very interesting and is rather important. In fact the item will come out of the quick access store in about 2 microseconds, but the actual reading destroys the record of the syllable. Normally you do not wish to destroy, so you have to go through some of the electronic motions to regenerate it. This act of regeneration takes you up to about 12 microseconds, so there are occasions, but not many when you want to read a thing and destroy it in which case you get a speed rather faster than the 12 microseconds, but I want to play safe and say the speed will be about 25 microseconds for an addition or subtraction of a syllable.

14 Multiplication would take about 3 milliseconds a syllable. Do not forget it might be that 4 syllables have to be processed, in which case addition takes about 100 microseconds and not 25, and multiplication time for 4 syllables is about 12 milliseconds.

15 Now if I add on the quick access store a control unit which takes orders from the quick access store in order to set the rest of the machine into a state for obeying that order, I have almost a computer, provided one has a means of putting numbers and instructions into the quick access store.

MAGNETIC TAPE UNITS

16 This is to be done from reels of magnetic tape, and you could vary the specification of the machine you order from one to about 16 magnetic tape units. These are connected so that you can either communicate from the tape to the quick access store (which is said to be an act of reading the tape) or from quick access store to the tape (which is said to be an act of writing on the tape). At the same time they are also connected so that you can read from the tape to a quick access store. This means you have the ability simultaneously to write on one and read on the other, but you cannot on a standard machine do more than that simultaneously.

17 The characteristics of the tape are as follows; packing density is 100 characters to the inch, and the speed of the tape is 100 inches per second, which gives you 10 000 characters per second at your running speed of the tape, in either direction, reading or writing. Stopping or starting time is about ten milliseconds in either case, to stop or to start. It is 8 channel tape, 6 of these for one of each of the six bits, one for parity check and the other for a clock pulse. Original input would be via a paper tape input which will run either 200 or 400 characters a second, according to what unit is available, or possibly via a punched card input.

PRINTING OUTPUT

18 We have now nearly built the computer, but there is as yet no means of the computer talking reasonably fluently to us, unless it talks on this magnetic tape. This is a UNIVAC class of machine because your results, or data, come in on the tape, are processed, and the results come back and are recorded on the tape. You then lift the tape off to a separate printing machine and print the results that have been recorded. This is quite sound when you are dealing with bulk results, such as payroll for 99.9% of your people, but there is always the odd .1% that you want to know about immediateley because something has gone wrong; either your basic data is wrong or, much less likely, the computer has gone wrong. This .1% may produce for some reason a negative payslip, for example; it is desirable to know about that at once, so we now hook up an electric typewriter for communicating exceptional cases and any other information from the computer. That is essential of course for those people, and there are some, maybe, who wish to make computers write their love letters for them directly!

INTERNAL STORAGE

19 We now have a totally adequate computer but it does want, I think in most cases, strengthening by more internal storage; one has the option of linking it to a magnetic drum and it would be standard to have one or two drums. I doubt whether there is very

much need for more than two; but I do not think there would be any difficulty in having more. You would probably find at the most two would be enough, because on each drum there would be 64 tracks, on each track will be 128 syllables. So that you should in all make 64 x 128 syllables into a quick access store, because I imagine you would need a large number of basic programmes and a certain amount of basic data, such as prices and so on. There is a two-way communication in tracks.

SORTING ON THE COMPUTER

20 Unless I went into a great deal of engineering detail which would only bore you, there is little more to be said on the machine as such, so I propose, by way of illustrating what I think you can do with the machine, to enter the sorting arena. I have heard two conflicting opinions on sorting on magnetic tape. One was said to me, in New York, by a man who was standing just by a UNIVAC which he had been using for eighteen months and which was regarded in his office as a piece of office equipment like you and I would regard a typewriter, and which had been fully integrated into his office and was performing extremely well. This computer was behind him; on his right were two more UNIVACs which were awaiting their acceptance tests and were going to be put into use on some planned programs already worked out for them. Further down the room was a space reserved for two more UNIVACs when they find the need for them. I said that I had heard these things were not very good sorters; he disagreed entirely with this point of view and said that they had done a lot of sorting on their UNIVAC, that it was most efficient and that the speed he expected to get out of it was comparable to that of a punched card machine for a similar sorting operation, but his sorting was more accurate, involved much less operator time and of course led straight on from some previous operation to the next operation without any change of machine or operator. He was very content.

21 However, in the Treasury O & M Bulletin recently there was a statement that there is a need for a separate magnetic tape sorting machine. I do not know who is right and who is wrong; I think that a magnetic tape machine is good for sorting some jobs and is not good for others.

22 We have done some figuring in Decca and I should like to say that I have some most valuable assistance from some of my colleagues in the audience tonight on this. I am going to make some odious comparisons of possible magnetic tape sorting speeds with punched card machines and I do this, not in an unfriendly spirit to punched cards lest I should insult any of my punched card friends in the audience, but because the punched card does give us a standard; it is not to be thought that I stand up here and denigrate punched cards.

23 I have got to make some assumptions, and I am sure that the value of whether there is any lesson to be learned in the figures I am about to put to you is contained in whether these assumptions are valid; this I must leave you to judge. There are four assumptions.

24 The first is that my tape has, as I described, a speed of 10 000 characters a second, based on a speed of 100 to the inch and a packing density of 100 to the inch.

25 The second assumption is that the arithmetic unit is so fast and is sufficiently large for you to take blocks in to it from the magnetic tape and find out which is the next item to go out to your magnetic tape so quickly that you do not hold up your magnetic tape; a standard block is assumed to hold 384 characters. This is why I said before that I regarded it as most important that your arithmetic unit should be ultra fast.

26 These two factors imply that the computer has to be very fast and has to be so large that when your tape is whizzing through there is always sufficient information inside it for the thing to get on and do something; it must not have to wait because there is insufficient information stored within it. What this really means in practice is that you must have sufficient buffering equipment so that you take numbers off the tapes and pass them right along till they are ready for output. If you have not got enough internal buffers or storage you get some holdups. I am assuming that I have sufficient buffers and can work so fast that at any one moment of time I am always reading one tape and writing on another.

27 Assumption number three is that I need 10 milliseconds for stopping or starting, and this implies that in 10 milliseconds the tape revolves one inch, so that I am leaving one inch between blocks on the tape to give the mechanism time to stop if circumstances arise in which it is necessary to stop between blocks: allowing one inch in which to start

up again. In total then we allow a two-inch gap between each effective block on the tape. I have got a bit up my sleeve because, of course, when it is told to stop, it does not maintain its full speed and stop suddenly; it starts decelerating so it does not require the whole of the inch to stop, but I do not quite know what effect that would have upon my figures so I am proceeding as though it requires the whole inch.

28 The fourth assumption is that I have got four tape channels on this machine and that I can read or wait whilst the tape is travelling in either direction. This is very important because the sorting technique involves reading tape into the machine and writing it our partially sorted; one then reads the newly written tape back and it comes out on another piece of the tape more sorted, so to speak; you go on like this until eventually you have completely sorted it. If when you are reading a partially sorted tape you can not go back in the direction the tape is wound, you have got to rewind that tape before you read it. This will cause the time to be nearly doubled; not quite doubled, if the rewind speed is faster than the reading speed. I am going to assume that the method of sorting is that after the first run anyway two tapes are taken in, and two are written out. You all know that there are various ways of sorting; I do not want to go into detail on the merits of the differnet methods but here will assume the use of a merging method. I believe that to be a method of general application but not necessarily always the best.

29 A certain number of strings, that is to say, items already in sequence, are included in the two tapes going in and when they come out the strings are twice as long as they were when they went in. Consequently every time you make one of these runs you halve the number of separate strings; when you have halved them long enough you will find you have only got one string, and at this stage the sort is completed. I also make an assumption, that in addition to these four tape channels I have got what you might call some stand-by channels, so that if I am dealing with a number of items which will not go on my standard sized reel, which is about 2 400 feet, I have got extensions standing by; one of these can be automatically switched in to continue any of the four standard units, but at no one time do we use more than four tapes.

30 I assumed (in the second of my basic assumptions) that a standard block holds 384 characters. This tape block therefore occupies about 3.84 inches; the gap will be about 2 inches and then another block is started. The total block plus the gap will be 5.84 inches which we will round up to about 6 inches. I have got .16 inches up my sleeve; it could be very useful. This 6 inches of tape will go through the computer in 60 milliseconds. It is implicit in the assumptions which I have made - and this is where you have to place some judgment on their validity - that the computer will process a block of information in 60 milliseconds, and that at the same time another block will be written out on one of the other tapes. I am therefore assuming that this 20 milliseconds is quite sufficient for all the computing that must be made to decide on which output tape the block that goes in must be written.

COMPARISON WITH PUNCHED CARD SORTING

31 If you accept that as valid you get the following kind of calculation. Let us sort N items; it has been proved elsewhere that the number of runs you need to sort N items is the logarithm of N to the base of 2. All that this means is that the number of runs is the highest power of 2 involved in N; for example, if N is 1 024, you find out that 2^{10} is equal to 1 024 and therefore 10 is the logarithm of N to the base 2. By the same token log 2 084 is 11, log 4 096 is 12 and log 8 192 is 13. You always select the next higher logarithm if N is not a precise power of 2.

32 Consider now the time for one run. I have made the assumption that the block is 384 characters; now some assumption must be made about the number of items per block. Suppose then the time per run is

$$\frac{N}{B} \times 60 \text{ milliseconds.}$$

Consequently, the total time is the number of runs multiplied by the time per run, or

$$\frac{60 \times \text{Log } N}{B} \text{ milliseconds.}$$

In minutes this is

$$\frac{N \times \text{Log } N}{1\ 000 \times B}$$

33 If I now assume that I am sorting on C columns, and that for the purpose of this calculation a punched card sorter is running at 600 cards a minute, then the time for N cards or items is

$$\frac{N \times C}{600} \text{ minutes.}$$

FIGURE 1 -

N	Log N	B = 1		B = 4		B = 8	
		Computer time Minutes	Criterion	Computer time Minutes	Criterion	Computer time Minutes	Criterion
1024	10	10	6	3	1	1	0
2048	11	23	6	6	1	3	0
4098	12	49	7	12	1	6	0
8192	13	106	7	27	2	13	0
Number of characters per item		384		96		48	

If you equate the computer time of

$$\frac{N \times \text{Log } N}{1\,000 \times B}$$

with the punched card time of

$$\frac{N \times C}{600} \text{ minutes,}$$

then you will find that the punched card time is greater than the computer time if C, the number of columns, is greater than

$$\frac{.6 \times \text{Log } N}{B} \quad .$$

34 You may not think that so far this advances our knowledge at all profoundly, so let us attempt to show what this algebra looks like in practice. First of all this comparison depends on B so let us take B = 1 for the moment; this is the case where we have one item in a tape block and the criterion becomes .6 x Log N. For 1 024 items we know that Log N is 10 and so for 1 024 items the critical number of columns is .6 x 10, or 6. The computer time of

$$\frac{N \times \text{Log } N}{1\,000 \times B}$$

is almost exactly 10 minutes. The meaning of these formulae is that it takes 10 minutes to sort 1 024 items on the computer and, if the number of columns sorted is greater than 6, then the computer does it more quickly than a punched card machine running at 600 cards a minute.

35 The table (Figure 1) shows the calculation for other values of N and B and the criterion of the number of columns above which the punched card sort takes longer on one sorter.

36 There are several interesting and to me surprising things which emerge from this table. One is that the more items you are sorting the better does the punched card machine compare with the computer. However, 384 characters per card may not be practical, so that the table for B = 1 is not very realistic. For B = 4 the indication is that the computer will be faster except where the number of columns to be sorted is 1 or 2; after looking at the table for B = 8 one might say that it is quicker not to sort on punched cards than it is not to sort on a computer. The table does bring out one advantage of tape or film, that the space occupied by the record is only about that really needed and consequently the speed is roughly proportional to the number of characters in the item.

37 The table must be regarded as illustrative of the situation which would obtain only if the assumptions I have made were fulfilled. The practical punched card speed, for example, may be more or less than 600 cards per minute; whatever it is, there is nothing to prevent it being increased by the introduction of more than one sorter and this should lead us to consider the relative economics of the two methods; however, though the economic aspect is relevant, I do not propose to take time to discuss it.

38 The most important aspect of the table is that the whole thing is theoretical; I have done a lot of work in the last sixteen years on machines both on paper and in practice and if there is one lesson I have

learned it is not to believe any predictions until you really see the machine working.

DECCA C1 AND C2

39 That leads me back to Decca's part in this and to explain that I am talking of theory and not practice based on an existing machine. When I was first approached by the London Computer Group - I think it was about eight months ago - the machine I would have talked to you about would have been called Decca C2 and would have been quite different from the machine I have just described to you. We were then engaged on making Decca C1, which was conceived as a machine made almost entirely of magnetic cores. Decca C2 would have been based on the same techniques as Decca C1. Now what has happened in the eight months that have elapsed since I undertook to give this talk was that on a further study of the cores we have come to the conclusion that they are most excellent objects with which to make quick access storage, shifting registers or buffers. We are now by no means convinced that they are the right thing out of which to make the entire arithmetic. We find that we can proceed and make the arithmetic unit but it would involve many more valves than we expected and this upsets the relationship between the price of the machine and the speed, as the only point of producing a medium speed machine is to produce it at a medium price.

40 I have, therefore, put before you in the earlier part of my talk this evening a machine which I believe could be made out of what one could today call established techniques. There is nothing frightfully exotic about it, but we have had to assess the time scale for making this machine and I would tell you that the part which is at an advanced stage of existence at this moment of time is the magnetic tape unit.

41 When we assess the time scale for building such a computer, I might say we have ceased to be optimistic in the last eight months; we find it may take something like two years to build a prototype and something of the order of another six months to test it, improve it and get it into a state when it is demonstrable. The next stage is to produce what people in the engineering business know as an engineered prototype and this can take another year. What I am trying to say is that such a computer is easily talked about but it is not a small undertaking to build it.

42 So we have to ask ourselves, as manufacturers, whether this is in fact the course we should pursue. Having spent a little time on the core machine (far too long, although I hope you will allow me to call it a courageous experiment), we have to decide whether to build a computer using established techniques or whether to use various new basic techniques which are just coming forward. The fundamental question is - can we make a better machine using new techniques in about the same time as if we used the established techniques?

43 We have been pondering this for a long time and we have come to the conclusion that we should adopt the very latest techniques. So you must think of the Decca C2 that I described in the earlier part of this meeting as a conception rather than as a physically existing computer; maybe that is why it is called the C2 because it is the second conception. And so at the moment I would not like to take the matter beyond what I have said tonight.

DISCUSSION

44 Will the tape unit to which you referred earlier be available for use with computers which are possibly of earlier design?

Yes.

45 Will you expand a little on the variable radix technique?

Consider the digits 1, 2, 3 and 1, 8, 9 and assume that they represent two sterling amounts 12/3d and 18/9d; they would each use a format syllable of 2, 10, 12. This format word is stored in the quick access store and before you make an arithmetical operation you send it to the arithmetic unit. This conditions the arithmetic unit to perform sterling arithmetic as opposed to, say, decimal. Had you required decimal arithmetic, then you would send a format syllable of 10, 10, 10 to the arithmetic unit. You then proceed as you do on any other computer and send the two numbers you are adding or subtracting to the arithmetic unit.

46 Do you use the same format word over and over again?

Yes. If you have many numbers expressed in decimals, you use exactly the same format for all of them. I hope I have not given the impression that you only get half usage out

of your storage because with every syllable you store a format word; this is not so. You store a format word only for every kind of arithmetic that you need to do on that particular job.

47 Is the machine limited to three syllables or not?

No, the machine would work directly with up to four syllable words; more than four syllable working could readily be programmed.

48 Could you use a price syllable and a quantity syllable?

It would not add a price to a quantity. When you send 123 or 12/3d. to the arithmetic unit, exactly the same pattern of pulses go to the arithmetic unit, but they are treated as 123 if it has been primed with 10, 10, 10 or as 12/3d. if it has been primed with 2, 10, 12.

49 Could you add 6 digit prices and quantities simultaneously?

No, not simultaneously; you can add six digits of price to six digits of price simultaneously, then you could change your format and add six digits of quantity to six digits of quantity.

50 In the comparison between punched card sorting and magnetic tape sorting, could you not take a little bit off the time for magnetic tape? In the process you described you start off with items in random order, you then produce your second set of tapes of two elements, then go back and produce strings of four and so on; can you not sort some of the items on the magnetic drum or in the quick access store? In other words, you would not pass to the magnetic tape until you have got strings of sufficient length?

Yes, I think you are quite right. I just did not want to be too unfair to punched cards or elaborate the scheme initially. May I add a corollary to that; there are many occasions where you sort now but where you would not sort at all if you had a magnetic film or machine. In an assurance company one might record 384 characters for each policy; if you want to sort these into age and sum assured, sum assured analysed by age, one could sort punched cards into age using two columns and then feed the cards through a tabulator. This would involve three runs through two machines. On the computer one would pass the tape through and in one run the items would be analysed. Thw whole job of analysis and addition would be completed in one passage without disturbing the basic record or creating a new one in a different order

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